31st Northern California Chapter of SAMPE
Composites Workshop & Sponsor Exhibition

COMPOSITE SELECTION in YACHT DESIGN

Jim Antrim
Antrim Associates, Naval Architects

HOW DO YOU LEARN THIS STUFF?

- Get a composites engineering program, Use it. Study the results. How do the different materials and fiber orientations affect the results
- Studying failures: *BROKEN STUFF!*
- Interaction with builders. What works, what is difficult, what sticks, what feels strong
- Intuition, common sense

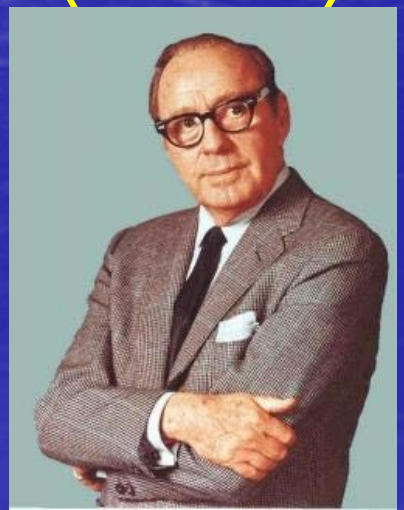
ENGINEERING CHOICES TRIANGLE

Antrim Associates, Naval Architects
www.AntrimDesign.com

DESIGN CHOICES TRIANGLE

credit: Dick Newick

PICK 2
or 1?



Antrim Associates, Naval Architects
www.AntrimDesign.com

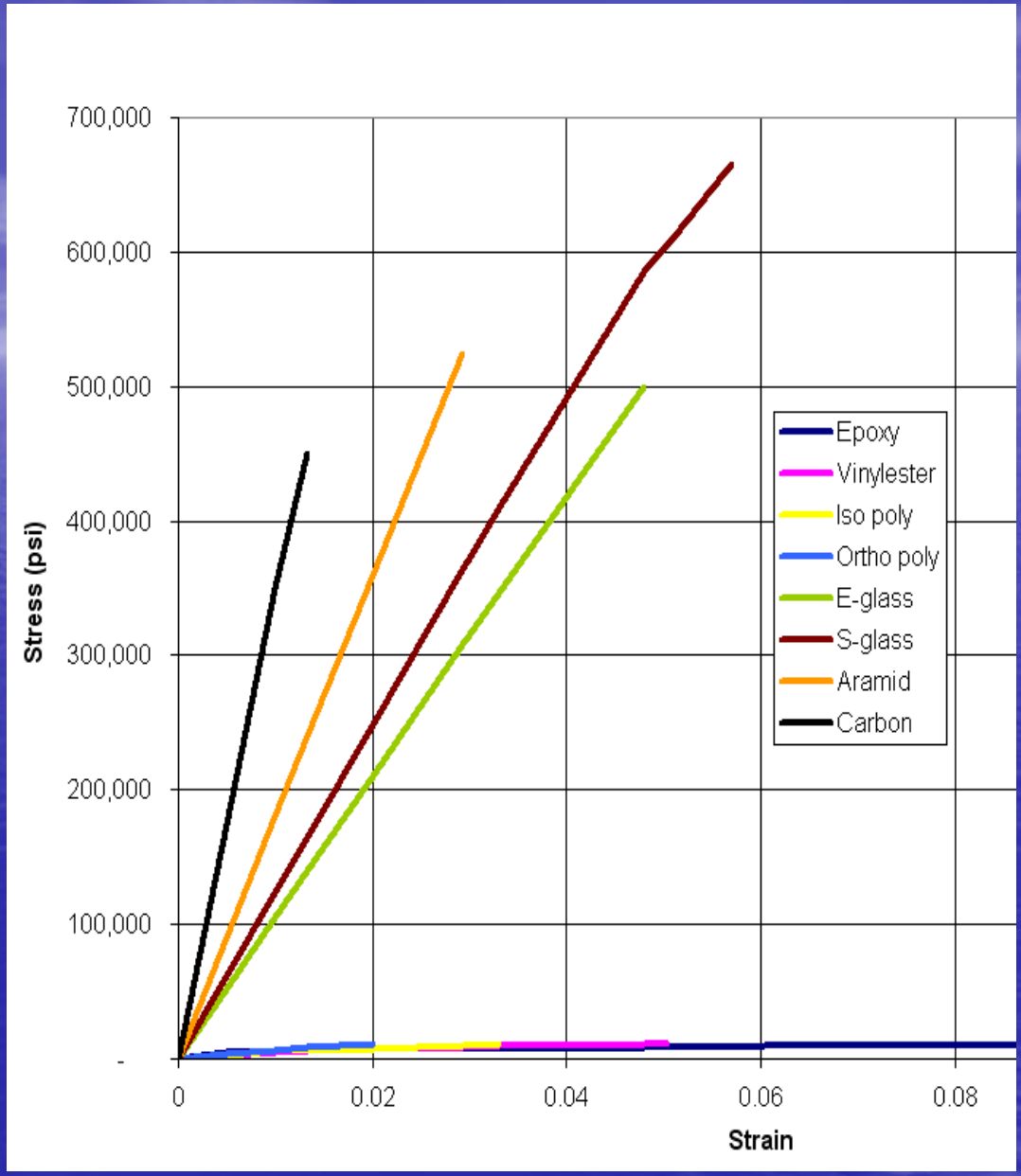
FACTORS AFFECTING MATERIAL CHOICE

- Cost, weight, stiffness, strength
- Builder experience, comfort level with materials or method
- Workability
- Durability, fatigue
- Chic, Coolness factor
- Rating Rule

Stress/Strain for Fibers & Resin.

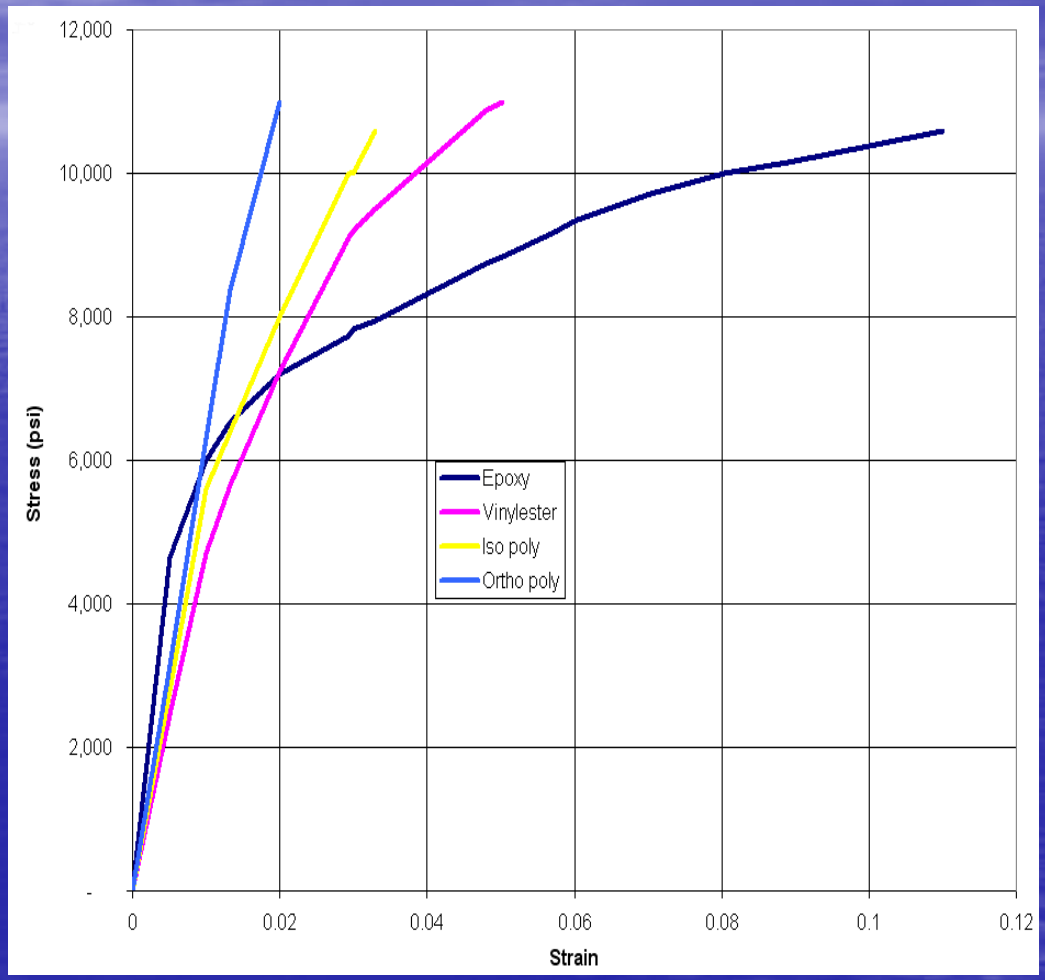
(Isolated, not in a laminate)

- Fibers do not yield
- Fibers are vastly stronger than resin. This is why "grain" direction is important
- Stiff fibers (e.g. carbon) carry high load at low strain (low stretch)
- Lower quality resins fail before fibers – fatigue & laminate strength limiting
- High quality resin have high strain. Fatigue is greatly reduced. Fibers can reach load capacity



Stress/Strain for various resin types

- Same plot as previous
- These are generic. Properties can vary significantly
- Ortho polyesters are typically stiff/more brittle. Strain to failure less than most fibers
- Vinylesters and Epoxies have much higher strain to failure, therefore less fatigue in a laminate
- More fiber strength is available when resin matrix has higher strain at failure



Use composites effectively

- Align fibers (“grain”) with the load
- Even when load path is well known, 100% unidirectional laminate is rarely wise.

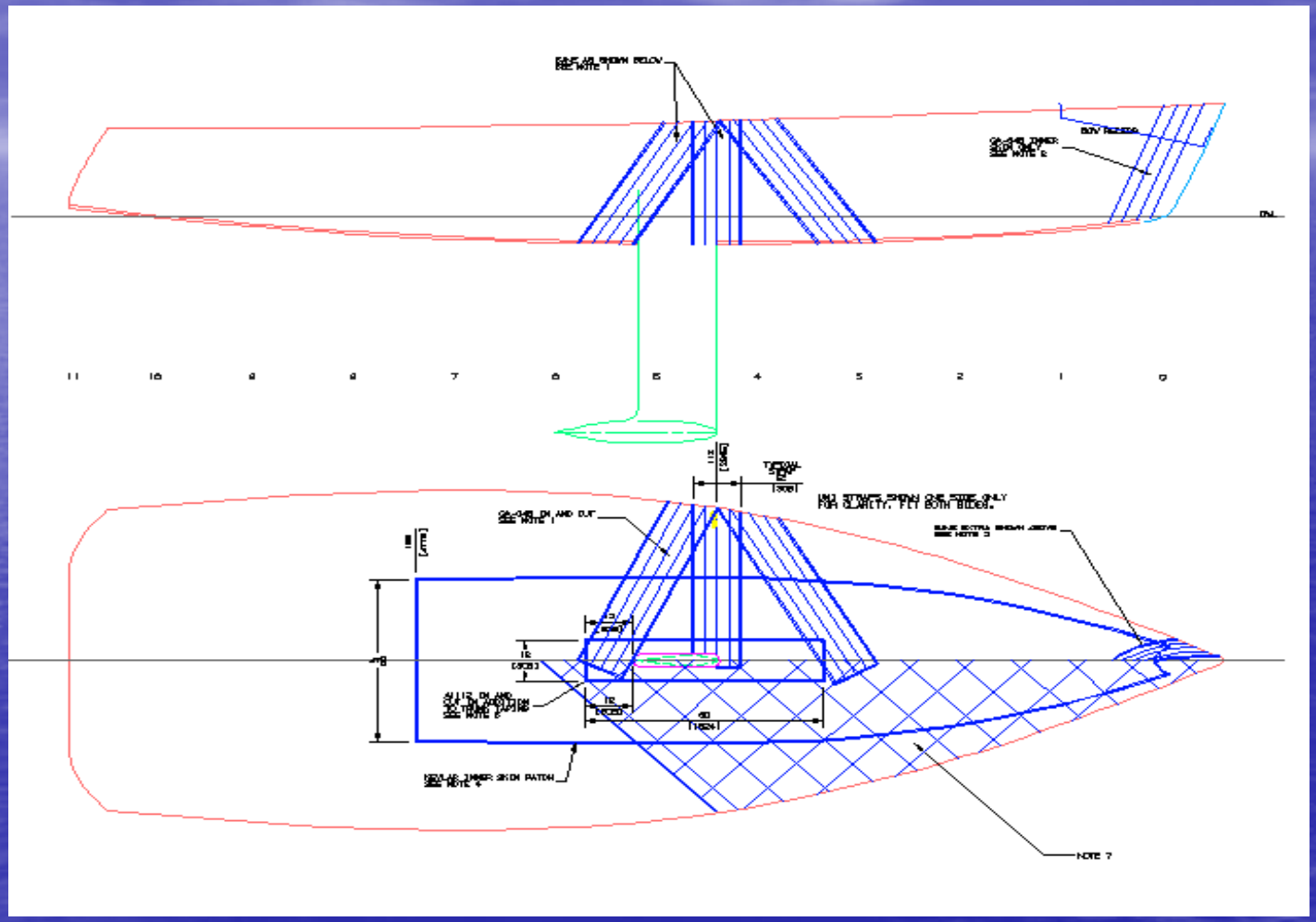
(Due to Poisson effects, at least 20% of fibers off axis is usually desirable when load path is clearly defined.)

- For panels, primary grain should run in the short direction across framing.

(For a wood floor, would you lay your planking across the frames or parallel to them?)

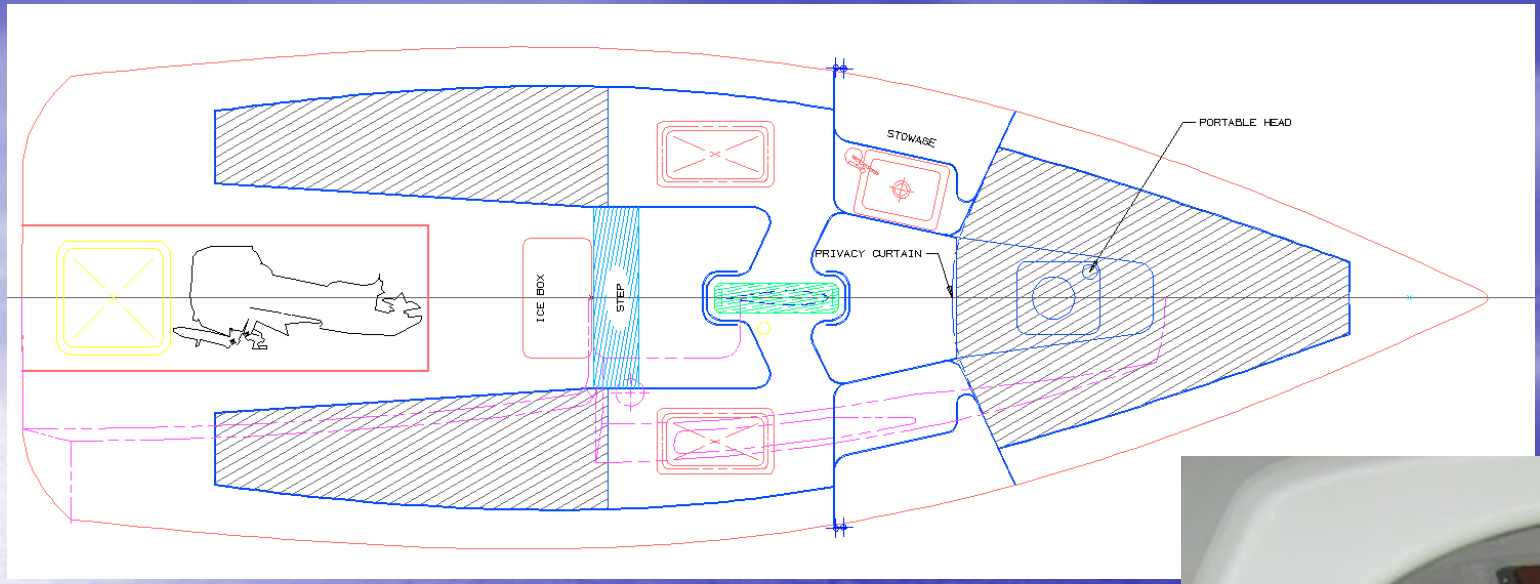
- Exotic, expensive material where it is most effective

Effective use of reinforcements in Ultimate 24 Sportboat



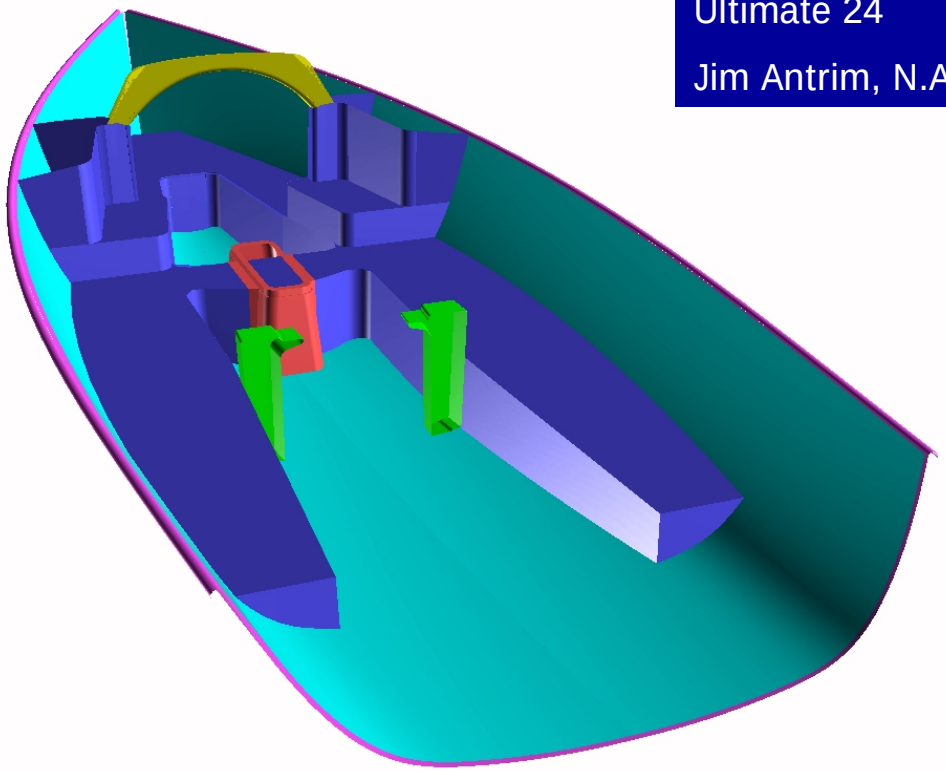
- Carbon uni strap aligned with primary loads: chainplate to keel, etc.
- Kevlar grounding patch in bottom
- Extra E-glass +/-45 biaxial in bow for collision and shear due to rig loads

Antrim Associates, Naval Architects
www.AntrimDesign.com

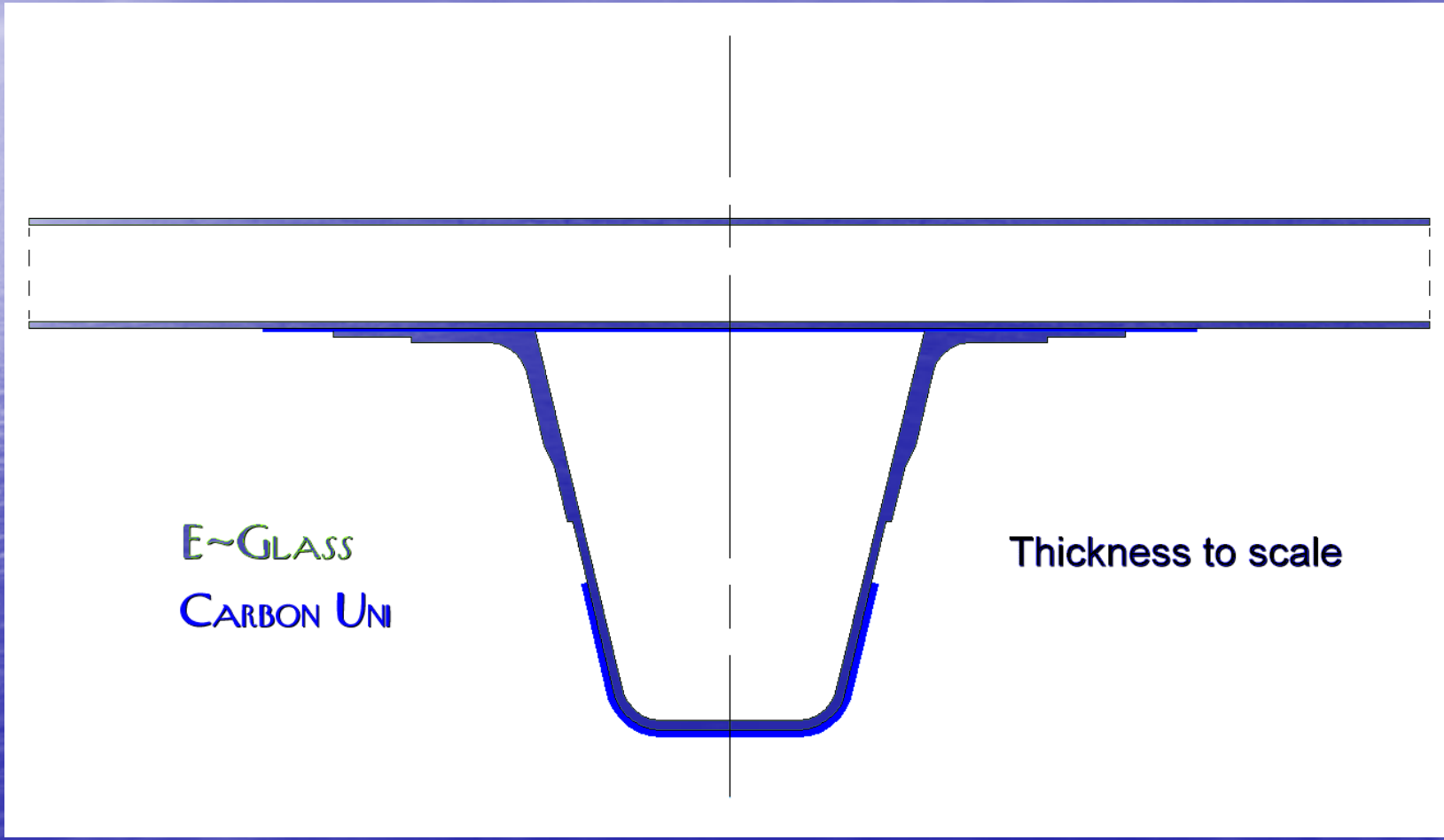


Ultimate 24

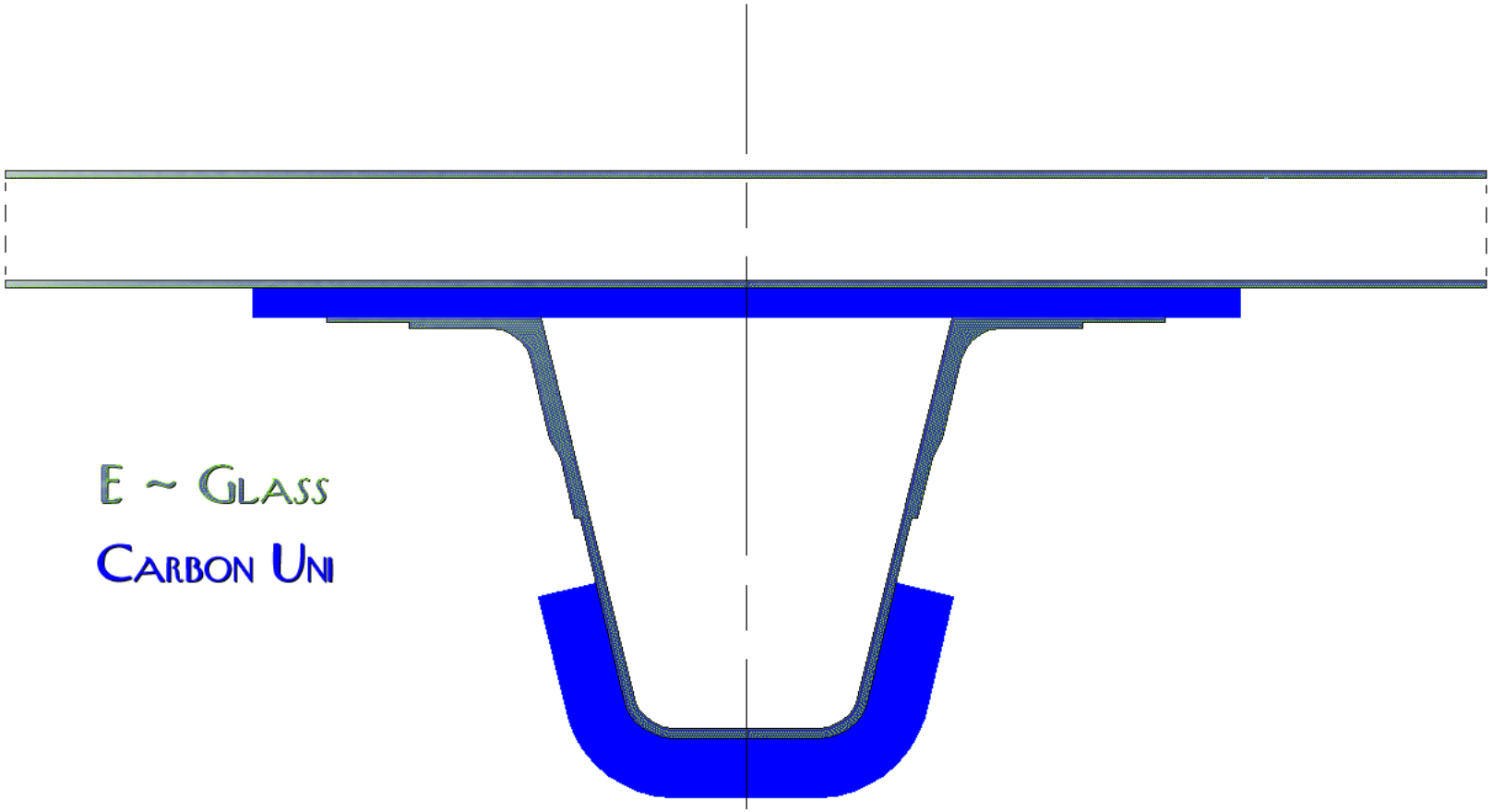
Jim Antrim, N.A.



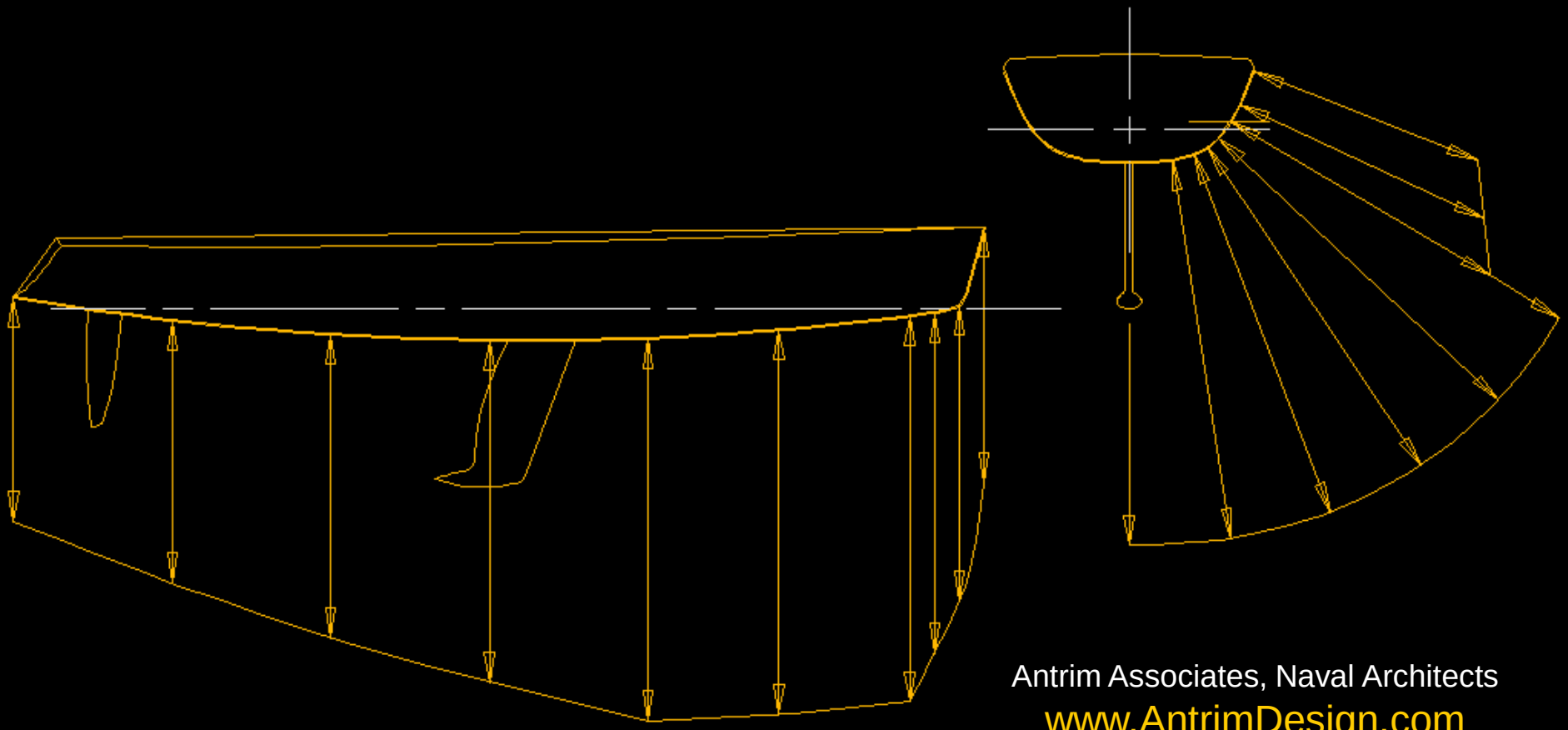
Effective use of high tech composites
Hat Section example



Thickness adjusted to EFFECTIVE area
(Area times Young's Modulus)



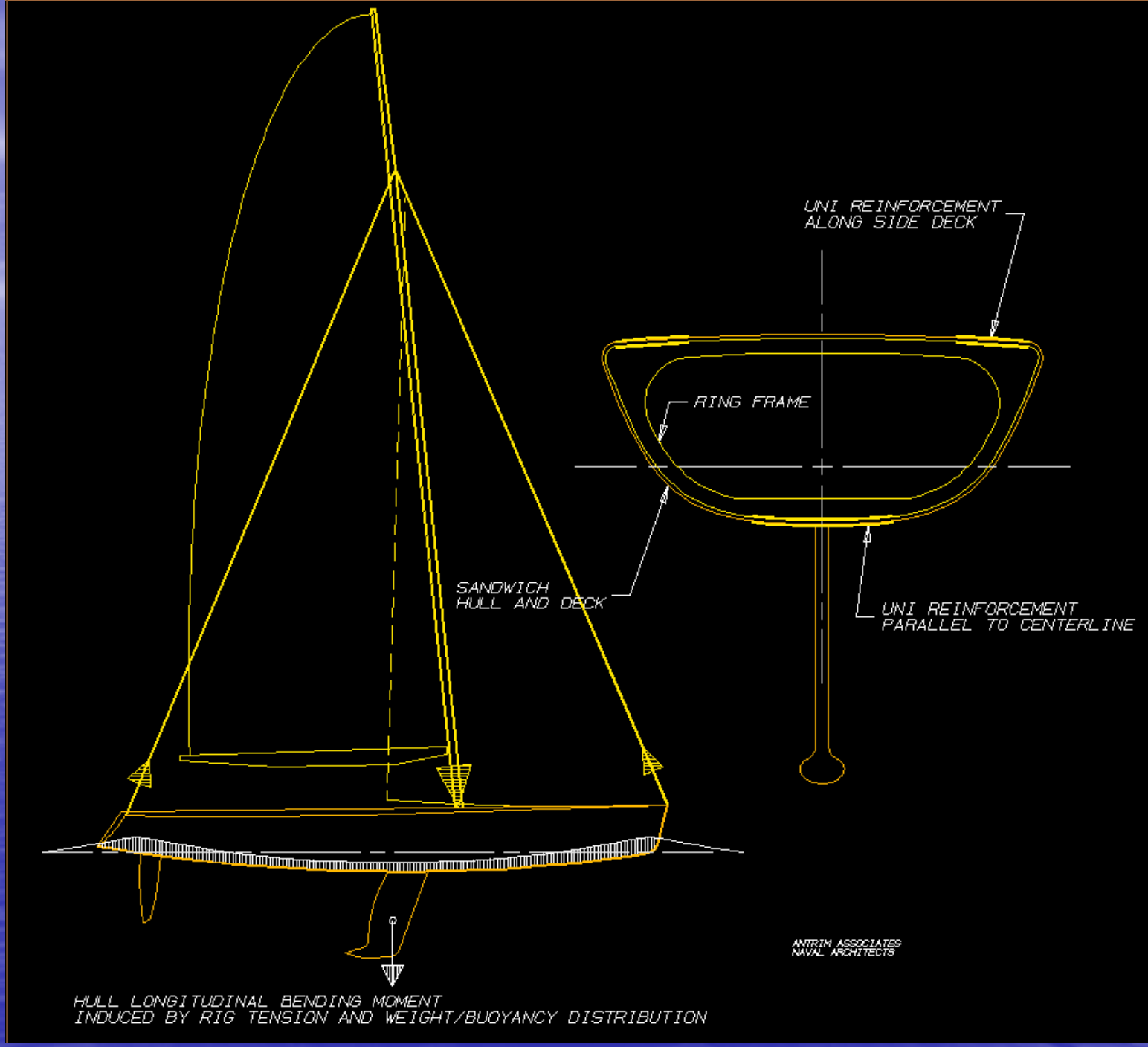
Water head (pressure) on a monohull sailboat



Antrim Associates, Naval Architects

www.AntrimDesign.com

Hull bending in a sailboat under imposed rig loads, wave loads, & keel weight

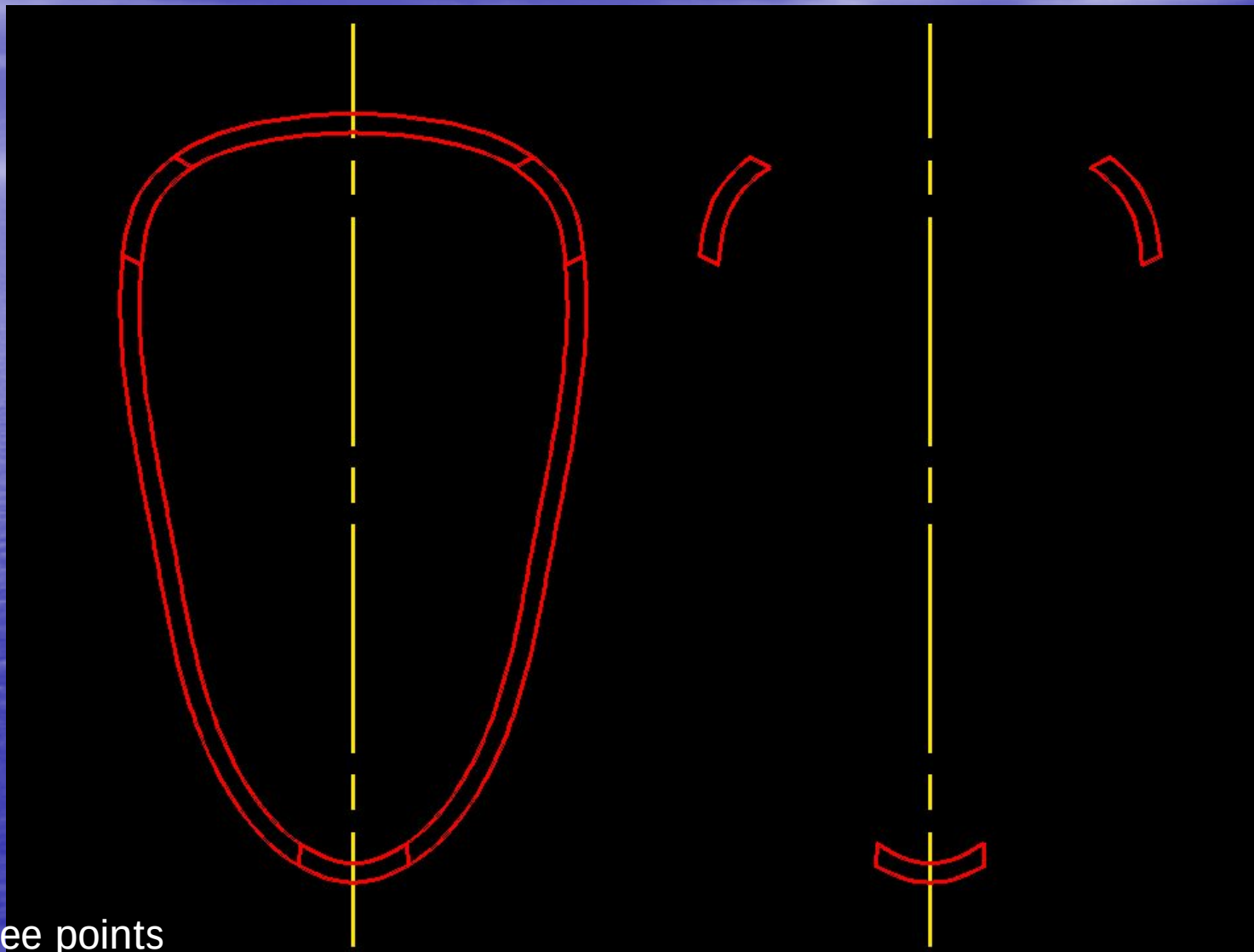


Perhaps we underestimated the hull bending loads?

Not Antrim Associates, Naval Architects

(though we have had mishaps on occasion too)

Great American II – bow failure



Carbon build-up, three points
But not always at extreme fiber location
Failure mode is skin buckling between carbon straps.

Antrim Associates, Naval Architects
www.AntrimDesign.com

Orienting fibers to the load

Many parts have obvious load path

- Tubes, such as mast, boom, bowsprit, rudder post, multihull crossbeams.
- Hull framing

Hull/Deck shell has varied loading

- Water pressure, crew & gear loads perpendicular to panel surface
- Hull bending loads in plane with panel

Bulkheads & ring frames have varied edge loading, shear

Billy Black photo

Antrim 40 trimaran *Zephyr*

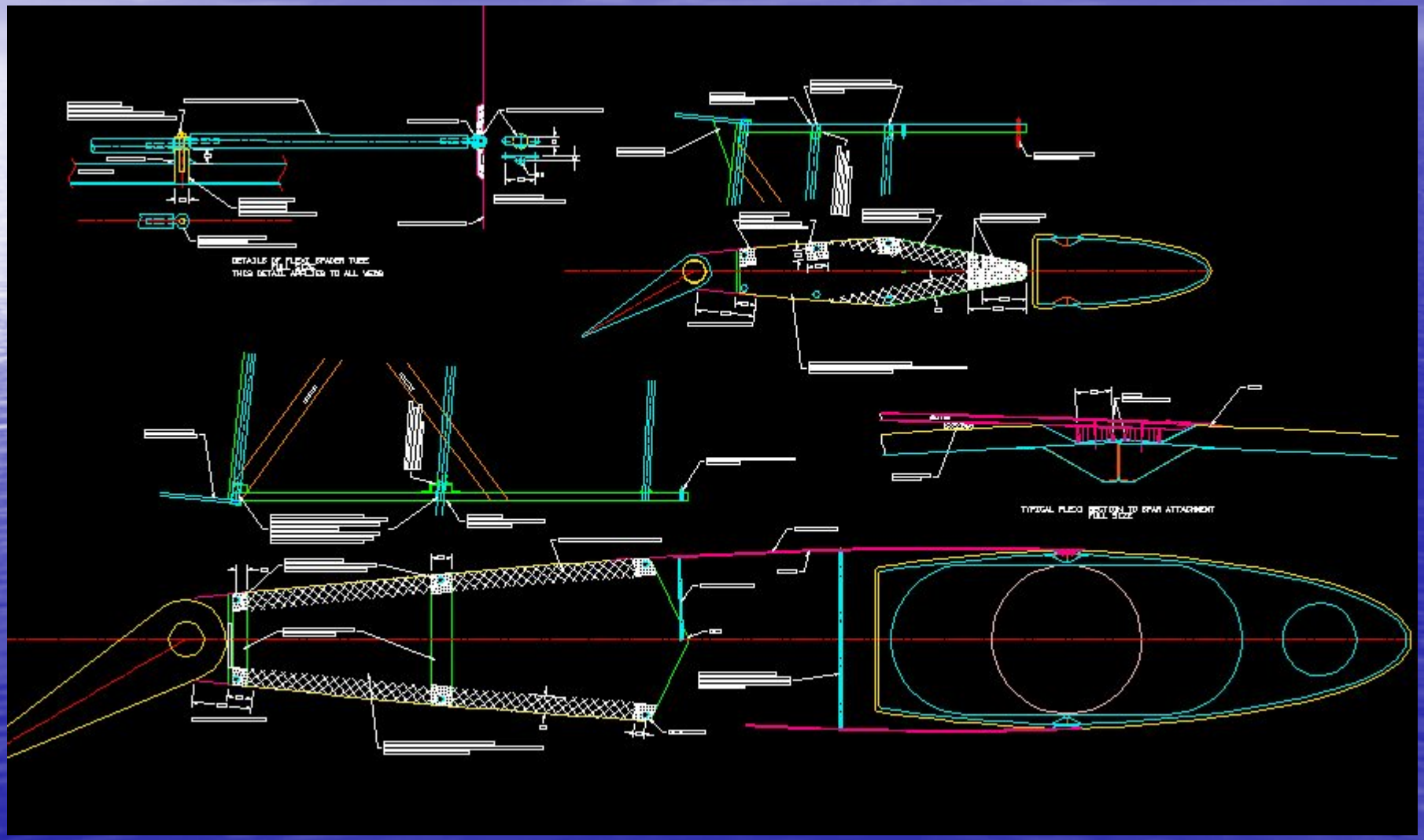
22m Catamaran “Te Marama” built in Raiatea

- Aluminum hulls
- Composite sandwich superstructure of glass, thin plywood skins, Divinycel core, carbon reinforced
- Plywood mold remains as part of structure
- Exotic wing with carbon/SuperLite balsa spar, filament wound carbon tubes, Kevlar/Tedlar skins

Antrim Associates, Naval Architects

www.AntrimDesign.com

Te Marama wing details



Open 50 “Everest Horizontal”

Around Alone 2002-2003

- Carbon pre-preg hull & deck, mast, boom, bowsprit, rudders
- SuperLite Balsa core
- Sponsored boat during construction
- Impact testing

Antrim Associates, Naval Architects

www.AntrimDesign.com